7.3.3 Cost to Alternative Media

7.3.3.1 Definition

The equipment cost for a cable system operator, or other alternative service provider, to deliver an ATV signal.

7.3.3.2 Method of Determination

Cable system equipment configurations are analyzed to determine cost variations due to differences in ATV proponent systems.

7.3.4 Cost to Consumers

7.3.4.1 Definition

The cost of manufacturing consumer ATV receivers.

7.3.4.2 Method of Determination

Based on analysis by SS/WP3. Develop assumptions for year and volume of production; type, size and resolution of baseline receivers (CRT and projection); and projections of IC capabilities and costs. System-specific receiver costs will be generated based on information provided by each proponent.

7.4 TECHNOLOGY CRITERIA

7.4.1 Background

The five selection criteria in this technology section relate to aspects other than spectrum utilization and economic considerations. Recognizing that the selection criteria are in general inter-related, the purpose in this section is to consider the aspects of these criteria that can be separated from the economic aspects and spectrum utilization aspects.

These technology criteria represent the measures of improved performance and additional capabilities that comprise much of the motivation for adopting a new television standard for the U.S. The audio/video quality criterion directly relates to consumer perceived quality of sound and images. The transmission robustness criterion measures the degree to which the system can continue to operate with anticipated impairments, while retaining acceptable sound and picture quality for the consumer. The scope of features and services criterion examines the capability of a system to support ancillary services and features that are currently available for NTSC transmissions, as well as anticipated improvements and new services. The extensibility criterion addresses the capability for a system to support future improvements such as increased picture quality, resolution or additional services, without requiring a complete revision of the underlying television standard. The interoperability criterion considers the degree to which an ATV system can be carried on a variety of transmission media, stored in and displayed on a variety of terminals and meets the needs of non-broadcast industries. These particular attributes also relate to present and future

The subjective tests are:

ATV Basic (Received) Video Quality
ATV Basic Audio Quality

In the video quality tests, the basic data consist of subjective test scores for the 23 video segments that have been developed to highlight, for non-expert observers, system performance on attributes such as static luminance resolution.

In the audio quality test, the basic data consist of subjective test scores for 10 audio segments selected to illustrate, for expert listeners, system performance over a wide range of critical programming.

The basic data, which express judgments of individual systems compared with corresponding judgments of the reference conditions, are presented in tabular and graphical form.

In addition, all objective test data was studied to ensure support of the subjective results, and to report anything that looks odd, interesting or is felt should be brought to the attention of the Advisory Committee for any reason.

7.4.2.3 Target Value

The CCIR has defined HDTV in terms of current television systems. That definition, applied to NTSC, leads to the following target value. The resolution should be about twice that of NTSC in both the vertical and horizontal directions, the temporal resolution should be not less than NTSC, the color rendition should be superior to NTSC, any artifacts should be less objectionable than are NTSC artifacts, the aspect ratio should be 16:9, and the subjective sound quality should be comparable to Compact Disc.

7.4.3 Transmission Robustness

7.4.3.1 Definition

The ability of a transmission system to maintain a useful received picture, sound, and data in the presence of co-channel, adjacent-channel, taboo channel, and discrete frequency interference; and such impairments as noise, multipath, airplane flutter, etc., for terrestrial broadcasting; and second and third order distortion, phase noise, etc., for cable transmission.[3]

[3] The results of the Susceptibility to Interference tests described in Section 19.5 of the Objective and Transmission Tests Procedures Plans will be taken into account as part of the coverage studies conducted by PS/WP3.

7.4.3.2 Method of Determination

Transmission robustness contains quantitative and narrative information based on the results from the appropriate test centers. The information includes:

Video Objective Tests with Expert Observation and Commentary
ATTC and CableLabs test results

Video Subjective Tests
ATEL test results

The robustness is determined not only by TOV and POU, but also the character of the impairment and a description of failure and recovery appearance.

7.4.3.3 Target Value

Better than NTSC within the defined service area.

7.4.4 Scope of Services and Features

This selection criterion addresses the need of an ATV system to support an array of services, features and capabilities beyond those that are explicitly considered as part of the other selection criteria.

Some capabilities covered here are features of the overall system. These include details of the picture and sound performance near the edge of coverage, the ability to operate in different modes of robustness versus picture quality, and the ability to reallocate channel capacity on demand among video, audio and ancillary services.

Other capabilities are specific features of the picture coding, sound coding or ancillary data capacity, other than quality or robustness. These include the support of various multi-channel sound formats, services for viewers with special needs, and the ability to support inexpensive receivers with NTSC-quality video.

Other elements of this selection criterion cover the work done by the Implementation Subcommittee, such as speed of implementation or other implementation features that are not cost-related and are not considered as part of the other selection criteria.

7.4.4.1 Definition

Services and features supported by a transmission system other than the program video and one program audio channel.

7.4.4.2 Method of Determination

Scope of services and features were evaluated based on information supplied by the proponents, supplemented by analysis done by working parties of the Advisory Committee.

An essential part of the evaluation takes into account whether the services and features have been implemented in the system that was submitted for testing at the Advanced Television Test Center. Services and features that are merely claimed but not yet implemented will be analyzed to evaluate how easy or difficult it will be to implement them. As part of the decision process, a determination will have to be made about how to evaluate these services and features that are claimed but not implemented.

7.4.4.3 Target Value

When compared with NTSC, increased capability and flexibility in the ability to provide audio, captioning, data services, etc.

7.4.5 Extensibility

7.4.5.1 Definition

The ability of a transmission system to support and incorporate extended functions and future technology advances.

7.4.5.2 Method of Determination

Based upon information from PS/WP4, declarations by the proponents and the judgment of industry experts.

7.4.5.3 Target Value

A new service must provide long life, just as NTSC has provided a long life, by supporting future enhancements and future technology advances.

7.4.6 Interoperability Considerations

Interoperability considerations include delivery over alternate media such as cable, satellite, VCR, and packet networks; transcoding with NTSC, film, and other video standards; integration with computers and interactive systems; and scalability and the use of headers/descriptors to accommodate a variety of applications.

7.4.6.1 Definition

The suitability of a transmission system for operation on a variety of media, in addition to terrestrial broadcasting.

7.4.6.2 Method of Determination

Based upon information from PS/WP4, declarations by the proponents and the judgment of industry experts, and results of tests for cable television operation.

7.4.6.3 Target Value

A new service should be "friendly" to alternate delivery media. Interoperability with Cable TV is mandatory. Interoperability with VCRs, satellite, computer, data communications, and telecommunications applications with simple interfacing hardware is also an objective.

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8. ANALYSIS OF SYSTEM DATA

Chapters 9 through 13 provide summaries and analyses of data acquired from four laboratories (Advanced Television Test Center, Cable Television Laboratories, Advanced Television Evaluation Laboratory, and Westinghouse Research) on the five simulcast systems tested. Additionally, they include conclusions reached by Advisory Committee working parties on matters extending beyond what can be measured in a laboratory or derived from laboratory data. After a brief description of the system, subsections relate to Spectrum Utilization, Economics, Technology, and System Improvements, primarily addressing the ten each of the 1,657 authorized and applied-for television facilities in the August 1, 1992 FCC data base. Interference-limited NTSC service areas were determined on the basis of a co-channel desired-to-undesired (D/U) ratio of 28 dB and first adjacent D/U ratios of -6 dB for interference from the lower adjacent-channel and -12 dB for interference from the upper adjacent-channel. Taboo considerations are based on threshold of interference (TOV) data from ATTC. Subjective tests at ATEL of co-channel interference from NTSC to NTSC showed that a 28-dB co-channel ratio corresponded to a CCIR impairment rating of 3 for NTSC stations using precise offset.[3] Accordingly, co-channel interference from ATV to NTSC is based also on impairment grade 3. NTSC receiving antennas beyond the City Grade Contour are assumed to have a front-to-back (F/B) ratio of 6 dB. No directivity is assumed for receiving antennas within the City Grade Contour. NTSC service is based on median f(50,50)[4] signal strength. f(50,10) propagation data are used for both NTSC and ATV interfering signals.

The outer limit of NTSC service, in the absence of interference, is considered to be the Grade B level. As specified by the FCC, the median field strengths corresponding to Grade B are: 47 dBu for low VHF, 56 dBu for high VHF, and 64 dBu for UHF.

The outer limit of ATV service in the absence of interference is that determined by the carrier-to-noise ratio yielding a CCIR impairment grade of 4. For digital systems, the f(50,90) signal strength is used for noise and interference-limited service calculations. Figure 8-1 provides receiver planning factors applicable to all ATV systems.

8.1.2 Allotment and Assignment Constraints Used in Analysis

The PS/WP3 analysis was conducted under two allotment scenarios (using both VHF and UHF channels for ATV stations, and using only UHF channels) and two sets of interference constraints (considering only co-channel interference, and both co-channel and adjacent-channel interference). In addition, the impact of taboos was assessed by recalculating coverage and interference for each scenario assuming the taboo performance measured in the laboratory. PS/WP3 has determined that the analysis should be considered in the following priority order: 1) co-channel and adjacent-channel interference, 2) co-channel interference only, and 3) co-channel, adjacent-channel and taboo interferences.

[3] The same subjective tests showed that a 40-dB co-channel ratio corresponded to a CCIR impairment rating of 3, and that 28 dB corresponded to a rating of approximately 2 for NTSC stations using the worst

	Low VHF	High VHF	UHF
Antenna Impedance (ohms)	75.0	75.0	75.0
Bandwidth (MHz)	6.0	6.0	6.0
Thermal Noise (dBm)	-106.2	-106.2	-106.2
Noise Figure (dB)	10.0	10.0	10.0
Frequency (MHz)	69	194	615
Antenna Factor (dBm/dBu)	-111.7	-120.7	-130.7
Line Loss (dB)	1.0	2.0	4.0
Antenna Gain (dB)	4.0	6.0	10.0
Antenna F/B Ratio (dB)*	10	12	14

* In addition to F/B ratio, a formula is employed for the forward lobe simulating an actual receiving antenna pattern.

Figure 8-1. Receiver planning factors applicable to all ATV systems.

While the analysis that includes taboo performance maximizes consideration of interference impacts, limitations in both test and analysis involving taboos cause the results to have more limited value. During test, measurements were taken at TOV, yielding overly stringent results. Further, maximum amplitude limitations of the laboratory test facility affected the completeness of taboo test results. Finally, the effect of taboo interference is exaggerated in the computer analysis since taboo performance was not used to optimize allotments/assignments.

The analysis that includes both co-channel and adjacent-channel interference maximizes interference considerations short of including taboos. Adjacent-channel performance reflects both system and tuner design considerations. Thus, to the extent that a proponent's tuner, as tested, was suboptimal, adjacent-channel performance of ATV may have been negatively impacted.

The co-channel interference only analysis removes all adjacent-channel constraints resulting in tracing having a range of perhaps 4 or 5 dB; the average between the peaks and troughs is taken as the threshold.

There were instances in the cable threshold of visibility tests for impairments on the digital systems where no range in which to increment/decrement existed, i.e. in a single decibel the impairment signal went from non-existent to strong. It frequently happened that the threshold choice was between quite strong impairment and none, in which case the strong impairment level was chosen as TOV. When a small range was encountered in ATTC or CableLabs testing, the experimenters confirmed the TOV by using a longer observation period of perhaps 2 or 3 minutes during which impairments might be noted.

8.2 ECONOMICS

8.2.1 Calculation of Cost to Broadcasters

Several assumptions were made about the state of the existing broadcast facility and about the capacity available for inclusion of new equipment. It was assumed, for instance, that the station's existing tower has sufficient capacity for installation of the new ATV antenna and transmission line; a new tower is not required. The station's equipment space was assumed to have room for additional gear without the need to add floor space, racks, power distribution, air conditioning, or other support services. Similarly, it was assumed that stereo audio facilities already exist in the station. Additionally, the analysis was based on the use of a compressed NTSC signal multiplexed into the same STL with the ATV signal, as opposed to construction of a totally new and separate microwave path to the transmitter.

A cost was developed for each item on a station block diagram for each of the proposed ATV systems. Where possible, the likely cost of an item was sought through surveys of manufacturers likely to produce that item. In the many cases where it was not possible to obtain expected costs of items from manufacturers or from comparable equipment in the marketplace, broadcast system designers estimated selling prices based on the relative complexity of the items.

Certain general assumptions were made about the design of the transitional station. These included a choice of uncompressed, HDTV-level interconnections for the interfaces between equipment in the system, a downconverter to NTSC for simulcast transmission, and an upconverter for programming originated in NTSC. Provision was made for ATV-quality station IDs plus graphics for announcements and commercial tags. The ability to record and play back programs and commercials was incorporated through the inclusion of a video tape recorder. Some signal routing was provided, although it may be limited in scope. Monitoring was assumed to be done with professional quality instruments.

The design of the minimal station assumed that programs that arrive in ATV form are downconverted elsewhere to NTSC and fed to the station separately for simulcast transmission. It was assumed also that much programming will originate in NTSC and will require upconversion. In addition, station IDs and graphics for announcements and commercial tags were assumed to be upconverted from NTSC. Thus, an upconverter was included in the system along with an encoder to provide compression of material that originates in NTSC. Because the encoder processes only signals that began as NTSC, it was assumed that it can be a simpler device than used in the transitional station to compress ATV-level signals. The videotape recorder, likely to be based on a consumer VCR, would operate with fully compressed signals. The ATV signal routing was assumed to be a patch panel. Monitoring was assumed to use computer displays rather than professional video monitors.

In the cost estimates, "Satellite Receiver, Demodulator, Decoder" includes an optical-to-electronic signal converter. "STL Subsystem" includes NTSC compressor (20 Mbits/sec), multiplexer, STL transmitter (QPSK), STL receiver (QPSK), demultiplexer, and ATV reformatter (error correction for STL plus addition of FEC for broadcast transmission). "ATV Transmission Subsystem" includes ATV transmitter ($300,000), panel antenna and transmission line ($300,000), ATV transmitter monitoring, and ATV off-air monitoring.

8.2.2 Calculation of Cost to Consumers

Cost estimates were based on a common format to compare the technical complexity and material costs of proponent system receivers. The following methods and assumptions were used as a basis for comparison:

Time Frame — Based on system selection in 1993 and subsequent field testing, 1998 was assumed as the time when mass production of HDTV receivers would achieve sufficient volume (1 million units cumulative).

Technology — Receiver cost was estimated consistent with predictions for 1998 improvements in key technologies such as displays, integrated circuits, and memories. For this cost study, second generation receiver designs were assumed which would utilize these improved technologies.

Volume — 1% market penetration, or approximately 1 million HDTV receivers would be built by 1998.

Tuners — The cost of the tuner was agreed to be $10 for standard phase noise requirements and $13 for an improved phase noise specification needed by some proponents.

Displays — It was generally recognized that the cost of the display would have a major impact on the cost of the receiver and that, therefore, the market study would be influenced by that cost more than by any other. As a result, considerable effort was expended to find accurate estimates. A cathode-ray tube (CRT) of widescreen 34" diagonal with near HDTV performance, costing $700, and a projector of 56" diagonal dimension using projection CRTs and HDTV optical components, costing $1050, were assumed.

Deflection, Power Supply and Video Output — For 34" interlaced scan systems with scan rates of about 32 kHz and about 20 MHz video amplifier bandwidth, a cost of $60 was assumed. For 34" progressive scan systems with scan rates of about 47 kHz and about 30 MHz video amplifier bandwidth, a cost of $73 was assumed. For 56" projectors, $176 was assumed for interlaced scan systems and $201 for progressive scan systems.

Memory — A cost premium of 40% over standard dynamic random access memory (DRAM) was assumed for high speed memory used in some systems.

Digital ICs — The proponents provided block diagrams, gate counts, and pin counts variability and inconsistency among the judges seriously impaired the sensitivity of this test. A special audio task force reviewed the data and specific tapes and recommended against their use in this report.

Audio impairment subjective test results showed many irregularities. The special audio task

S7	Fruits & Vegetables	Color gamut
S8	Toys	Chrominance dynamic range
S9	Girl with Toys	Peripheral performance, interference, demo image
S10	Memorial Arch	Depth portrayal
S11	Woman with Roses	Noise impairment, interference
S12	Lorain Harbour	Noise impairment
S13	Flower on Plate	Multipath

ID	Electronically Generated	Test Application
S14	Cheshire Cat	Basic received quality

ID	Motion Sequences	Test Application
M1	Window	Basic received quality, luminance resolution, low acceleration
M2	Fax Machine	Basic received quality, dynamic luminance resolution, high acceleration
M3	Paint Store	Basic received quality, dynamic chrominance resolution, low acceleration
M4	Mannequins	Basic received quality, dynamic chrominance resolution, high acceleration
M5	Living Room	Basic received quality, motion rendition - camera movement
M6	Den	Basic received quality, motion rendition - single object in-scene movement, noise impairment, interference
M7	Park Ride	Basic received quality, motion rendition - multiple object in-scene movement
M8	Bubbles	Basic received quality
M9	Audience	Basic received quality, motion rendition - multiple object in-scene movement
M10	Woman & Room	Basic received quality, motion rendition - camera and in-scene movement combined
M11	Lamp	Noise and other impairment, demo image
M12	Times Square	Multipath and microreflections
M14	Co-Channel (Texas Dude)	Desired for co-channel, adjacent-channel, & taboo channel interference, Desired/Undesired for ATV-into-ATV, demo image
M15	Interferor	Undesired for ATV-into-NTSC and NTSC-into-ATV interference for Enhanced NTSC, Undesired for "benchmark" co-channel NTSC-into-ATV TOV for

M16G	Rotating Pyramids Gated	Undesired for NTSC-into-NTSC, NTSC-into-ATV, and ATV-into-NTSC interference for simulcast

ID	Film Origination	Test Application
M17	Carousel	Basic received quality, film transfer, 35 mm/24 fps
M18	Bridge 24 Frames	Basic received quality, film transfer, 35 mm/24 fps
M19	Bridge 30 Frames	Basic received quality, film transfer, 35 mm/30 fps
M20	Helicopter	Basic received quality, film transfer, 70 mm/60 fps

8.3.3 Inverted Picture Quality Results

The processed images for two electronically generated graphic sequences were judged during subjective testing to be higher quality than the reference. For the first of those, a still, S14, the processed image was judged to be better than the reference for all systems. For the second, a motion sequence, M16, the processed image was judged to be better than the reference for the 787 progressive systems.

In S14, interline flicker appears in the 1125 interlace reference. The flicker is reduced in processed interlace images, since, in effect, those systems vertically filter the image. No flicker appears in the 787 progressive source and processed images. Additional vertical filtering during the creation of the image could have significantly reduced the source interline flicker and possibly eliminated the rating inversion.

In M16, interline flicker appears in scrolling text in both the 1125 interlace reference and the interlace processed images. No flicker appears in the 787 progressive source and processed images. Since the flicker is a motion-related artifact, additional vertical filtering during image creation would not eliminate the flicker.

8.3.4 787 Camera Source Noise

The 787 camera-generated material used in tests of two of the systems exhibited visible noise in areas of low luminance. This noise, which was coarse in appearance, was more visible than the noise in the corresponding 1125 reference material, and the 1050 test material which was derived from the 1125. In addition, frame-by-frame examination of the 787 material revealed horizontally coherent noise that appeared as short, dark streaks.

Before the cameras were used by PS/WP6 in shooting the test sequences, the 787 camera noise level was measured to be about 2 dB worse than the 1125 camera. A noise level difference greater than 2 dB was observed in the source material during subjective testing, possibly as much as 5 or 6 dB. Also, differences in black levels between the 787 material and 1125 material have been noted. While the differences in black levels were not documented during the shoot, PS/WP6 personnel recall that there was a difference. The black level difference, in conjunction with gamma correction, could account for the unexpected additional level of noise in the 787 camera material.

It is believed that the additional source noise adversely affected the basic received quality test results for all motion sequences except for M16. However, the additional source noise, while significant, does not fully account for picture quality performance differences obtained by the two systems tested with this material.

8.3.5 Resolution Measurements

The limiting resolutions of the ATV systems were measured using a variety of techniques. Static and dynamic moving zone plates were photographed and viewed directly from a CRT to measure resolution. In addition, radial resolution charts which contained printed resolution numbers were captured with the cameras and stored on tape. Radial patterns from these charts were captured also at several speeds of rotation. The test results exhibited inconsistencies among the various techniques. The presence of coding artifacts and/or moire in some instances is known to have affected the consistency of the measurements.

Digital coding artifacts were visible to varying degrees in the dynamic zone plates due to the presence of high spatial frequencies over a large area coupled with non-linear motion (not panning). Since coding artifacts do not necessarily result in apparent loss of resolution, their presence obscures the limiting resolution and can result in a non-monotonicity as a function of speed.

In the case of the radial resolution charts, moire was visible sometimes at spatial resolutions lower than the expected limiting resolutions of the systems.

Because of the inconsistencies, and the interpretation problems caused by coding artifacts, objective measurements of video resolution are not included in this report.

8.3.6 Random Noise Determination (C/N)

Since the outer limit of service of an ATV system, in the absence of interference from other generators of electromagnetic energy, is dependent on the system's robustness with respect to noise, noise power input where video or audio are affected is an important metric. At ATTC, a broadband noise source, with flat energy distribution over the 6-MHz television channel, was used. Employment of an average-reading power meter and an RF step attenuator provided the ability to measure the amount of noise power being injected into the system.

Random noise measurements on the ATV systems was done at the strong desired level to avoid effects of receiver noise factor or any other elements that may have impact on the results. As agreed by the proponents, the strong receiver input level was set at -28 dBm for the Narrow-MUSE analog system and -38 dBm for the four digital systems. For the analog ATV system, power level varies with modulation and, unlike NTSC, no constant sync pulse level is available. At the proponent's suggestion, white level was adopted as the reference. In Narrow-MUSE, positive modulation is used, so white level is higher than black level.

In general, digital system average power levels are independent of picture content. The DSC-HDTV power level, however, being dependent on the split between 2-level and 4-level VSB modulation, required a particular reference signal for calibration. The reference signal used was a gray field. For the remaining three digital systems, the average power was measured during whatever scene was being employed in the test. Desired power was held constant at the strong level and the noise power was increased to determine the TOV and the POU (point of unusability).

For the analog system, sufficient separation was found from TOV to POU to permit ranging, so subjective tests were performed by ATEL. For the four digital systems, the spread from TOV to POU was insufficient to permit ranging, so the TOV was used to determine the C/N for the limiting case.

8.3.7 Interoperability Considerations

Computers are expected to play an increasing role in video image generation and production and it is desirable to have an HDTV format which facilitates easy display and manipulation of decompressed HDTV video on the computer. Progressive scanning and square pixels are important factors for interoperability of an HDTV system with computers — nearly all bit-techniques are not specified in the MPEG standards. The groups consist of diverse representation from among computer, telecommunications, television, and other industries worldwide. Their basic method consists of selecting the compression techniques that produce the best video and audio quality, based on mean squared error comparison of source and coded pictures and/or subjective expert evaluation of results from computer simulation.

The MPEG video and audio standards were nominally developed for 30 frames/second progressive scan, low resolution video (352H x 240V) at 1.5 Mbits/sec data rate, and stereo audio at a 256 kbits/sec data rate. Header/descriptors incorporated in the standards, however, allow modification of the nominal parameters, including changes in picture size, resolution and aspect ratio, pixel aspect ratio, frame rate, and compressed data rate. The MPEG standards (IS11172-1 [system], IS 11172-2 [video] and IS 11172-3 [audio]) were officially adopted by ISO in 1992. MPEG-1 video compression uses a bi-directional motion compensated Discrete Cosine Transform, and MPEG-1 audio compression uses adaptive Subband Coding. Compatibility between MPEG-1 encoders and decoders can depend on

The proposed improvement is approved with lab testing recommended after system selection, but before field testing.

The proposed improvement is approved with performance verification at the start of field testing.

The proposed improvement is classified as a "future" improvement since it would not be available until after field testing.

The improvements that were approved by the Technical Sub-Group are presented in the associated system analysis chapter, grouped according to the following categories:

1. Already Implemented
2. Implemented in Time for Field Testing

Improvements that were classified as "future" improvements were neither approved nor disapproved and are not listed in this report.

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9. NARROW-MUSE

9.1 SYSTEM OVERVIEW

Narrow-MUSE, proposed by NHK, the Japan Broadcasting Corporation, uses analog pulse-amplitude-modulation transmission for the visual signal, and digital transmission for sound and auxiliary data. By pre-processing and filtering, an 1125-line interlaced format is converted to a 750-line interlaced format, and then the converted signal is encoded into the Narrow-MUSE format using the Multiple Sub-Nyquist Sampling Encoding method. The field rate is 60.0 Hz. Aspect ratio is 16x9. The baseband spectrum of the stream of pulse-amplitude-modulated pulses produced by the video encoder is divided into two portions. The low video frequencies, to 0.75 MHz, which carry most of the video power and also the synchronization information, are modulated via VSB-AM on a carrier located 200 kHz above the lower band edge. This carrier placement means that this portion of the Narrow-MUSE modulated signal is attenuated by the Nyquist filter in an NTSC receiver tuned to the same channel, thus limiting interference into NTSC sets. The high video frequencies (from 0.75 MHz up), which represent the fine detail in the Narrow-MUSE picture, are modulated via SSB-AM, occupying a band extending from 1.42 MHz to approximately 6 MHz above the lower band edge. A gap in the spectrum from 1.1 MHz to 1.42 MHz is designed to minimize interference to and from co-channel NTSC. The Narrow-MUSE system has four channels of audio with 15 kHz bandwidth per channel. A near-instantaneous companding DPCM method is used for the audio. The audio is sampled at 32 kHz with 15 bit precision. Audio and auxiliary information are coded into ternary symbols for digital transmission.

9.2 SPECTRUM UTILIZATION

The Narrow-MUSE analysis was conducted under two allotment scenarios (using both VHF and UHF channels for ATV stations, and using only UHF channels) and two sets of interference constraints (considering only co-channel interference, and both co-channel and adjacent-channel interference). In addition, the impact of taboos was assessed by re-calculating coverage and interference for each case assuming the taboo performance measured in the laboratory.

Figure 9-1 shows planning factors, specific to the Narrow-MUSE system, as derived from test results. The numbers in the figure are desired-to-undesired ratios (D/U) in dB. The values for interference into NTSC are based on CCIR Impairment Grade 3 (slightly annoying) as determined from the ATEL subjective tests. Because the ATV service is intended to be an improvement over NTSC, interference into ATV is based on CCIR Impairment Grade 4 (perceptible but not annoying) if the range between the threshold of visibility (TOV) and the point of acquisition (POA) exceeds 5 dB. Otherwise, the TOV power level is used. Narrow-MUSE demonstrated a "graceful degradation" and thus D/U values are based on CCIR Impairment Grade 4. PS/WP3 set the maximum ERP at 37 dBk for Narrow-MUSE.

Co-Channel	D/U (dB)
ATV-into-NTSC	+16.8
NTSC-into-ATV	+21
ATV-into-ATV	+31

Carrier-to-Noise	+38

Adjacent-Channel	D/U (dB)
Lower ATV-into-NTSC	-31
Upper ATV-into-NTSC	-12.0
Lower NTSC-into-ATV	+28
Upper NTSC-into-ATV	-11.8
Lower ATV-into-ATV	-15.5
Upper ATV-into-ATV	+16.6

Figure 9-1. Planning factors specific to Narrow-MUSE.

9.2.1 Accommodation Percentage

Narrow-MUSE could provide 100% accommodation under both the VHF/UHF and UHF scenarios only if adjacent-channel and taboo constraints are not considered. Test results reveal that Narrow-MUSE cannot be collocated with a lower adjacent NTSC allotment, nor with another adjacent ATV allotment. Furthermore, the n+2 taboo for NTSC-into-ATV cannot support collocation and should be considered in developing an allotment/assignment table. Accommodation is achieved at the expense of reducing the ATV and NTSC service areas. No attempt was made to reduce interference to NTSC service by adjusting either ATV

Figure 9-3 shows the interference statistics for the VHF/UHF scenario. During the transition period, 8.6% of ATV stations would receive no interference. This would rise to 16.4% after the transition period ends. Also during the transition period, 61.6% of the ATV stations would receive interference in more than 35% of their noise-limited coverage area. This would fall to 49.5% after the transition period ends. The total interference area created within the ATV noise-limited coverage area during the transition period is 13.71 million square kilometers. This would decrease to 11.30 million square kilometers after the transition period ends. Of the existing NTSC stations, 74.4% would not receive any new interference because of the ATV service, while 0.5% would receive new interference in more than 35% of their Grade B area. The total new interference into NTSC created under this plan is 0.80 million square kilometers.

When the adjacent-channel constraints of Figure 9-1 are not included in the VHF/UHF scenario, the allotment/assignment table is different. In that case, 3.3% (55) of the ATV stations would have an ATV service area at least 20% larger than their companion NTSC service area and 41% (680) would have an ATV service area at least 80% of their companion NTSC service area. During the transition period, 19.1% of ATV stations would receive no interference. This would rise to 23.5% after the transition period ends. Also during the transition period, 27.9% of the ATV stations would receive interference in more than 35% of their noise-limited coverage area. This would fall to 27.1% after the transition period ends. Of the existing NTSC stations, 81.1% would not receive any new interference because of the ATV service, while 0.7% would receive new interference in more than 35% of their Grade B area.

Figure 9-4 depicts the interference-limited service area of each ATV station, during the transition period, relative to the interference-limited service area of its companion NTSC station under the UHF scenario, taking into account both co-channel and adjacent-channel constraints. In this graph, as before, the 1,657 current NTSC stations are placed in order of decreasing ATV to NTSC service area ratio. Examination of the graph reveals that 0.8% (12) of the 1,571 accommodated ATV stations under this scenario would have an ATV service area at least 20% larger than their companion NTSC service area and 16.0% (251) would have an ATV service area at least 80% of their companion NTSC service area. The total ATV interference-limited service area for the 1,571 stations is 18.8 million square kilometers.

Figure 9-5 shows the interference statistics for the UHF scenario. During the transition period, 7.8% of ATV stations would receive no interference. This would rise to 14.2% after the transition period ends. Also during the transition period, 64.0% of the ATV stations would receive interference in more than 35% of their noise-limited coverage area. This would fall to 52.7% after the transition period ends. The total interference area created within the ATV noise-limited coverage area during the transition period is 13.80 million square kilometers. This would decrease to 11.54 million square kilometers after the transition period ends. Of the existing NTSC stations, 77.7% would not receive any new

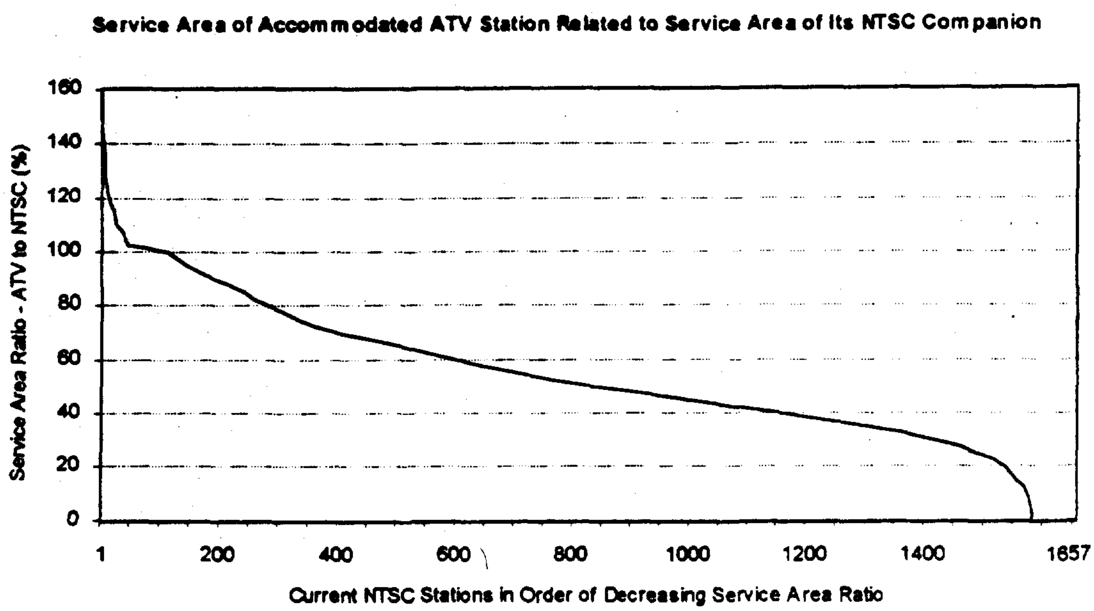

Figure 9-2. Narrow-MUSE VHF/UHF Scenario — Interference-limited service area of each ATV station relative to the interference-limited service area of its companion NTSC station (co-channel and adjacent-channel constraints).

Interference Area Compared to Coverage Area	ATV Stations with Interference		NTSC Stations with Added Interference Due to ATV
	During Transition	After Transition	
No Interference	8.6 %	16.4 %	74.4 %
0 - 5 %	2.9 %	4.2 %	10.9 %
5 - 10 %	3.4 %	4.0 %	6.6 %
10 - 15 %	3.1 %	4.0 %	3.6 %
15 - 20 %	4.0 %	3.9 %	1.9 %
20 - 25 %	4.1 %	4.9 %	1.1 %
25 - 30 %	5.6 %	6.2 %	0.8 %
30 - 35 %	6.7 %	6.9 %	0.2 %
> 35 %	61.6 %	49.5 %	0.5 %

Figure 9-3. Narrow-MUSE VHF/UHF Scenario — Interference characteristics (co-channel and adjacent-channel constraints).